October 1963

U.S. FOREST SERVICE
RESEARCH NOTE RM - 12

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

An Inexpensive Runoff Plot[1]

George Garcia,[2] Wayne C. Hickey, Jr.,[2] and E. J. Dortignac[3]

To develop desirable land-management practices for various plant or soil conditions, it is often desirable to measure surface runoff and erosion. This is particularly true in the arid and semiarid Southwest where plant cover is sparse, exposed bare soil prevalent, and rainstorms are commonly torrential.

In 1959 plots were installed on the Rio Puerco drainage in New Mexico to evaluate the effect of soil pitting and soil ripping on surface runoff and erosion. An inexpensive type of runoff plot and a simple method of installation was necessary to conduct the study. Precedent was discarded because cost prevented the use of expensive metal or concrete borders, elaborate runoff-water and sediment-collection troughs, and costly catchment or storage basins.

[1] Research reported here was conducted in cooperation with the Bureau of Land Management, U. S. Department of the Interior.

[2] Research Foresters, located at the Station's project headquarters in Albuquerque, in cooperation with the University of New Mexico; central headquarters are maintained at Fort Collins, in cooperation with Colorado State University.

[3] Formerly Research Forester, located at Albuquerque; now in Watershed Management Division, U. S. Forest Service, Washington, D. C.

SIZE AND SHAPE OF PLOTS

The ideal plot for measuring surface runoff and erosion is a miniature natural watershed. Unfortunately, watersheds of similar size and shape with homogeneous soil, geology, plant cover, and microclimate are seldom available. Each watershed is a distinct entity and behaves in a separate manner in regard to runoff and erosion. This is also true of surface runoff plots with artificial boundaries or borders. Yet, plots do provide an opportunity for testing or evaluating different plant treatments and conditions on areas with reasonably similar soil, geology, and microclimate.

Size of plot has a marked effect on the measured runoff and erosion. But the actual amount of surface runoff and erosion from plots is less important than measured differences between plots or treatments.

Runoff plots have been built in a square or rectangular shape. Square plots have the advantage that the ratio of plot border to plot area is less than for rectangular plots. The main advantage of a rectangular plot is that a longer slope is provided for a given area.

In this study, it was decided that each plot (fig. 1) should be at least 10 feet wide to reduce border disturbance and border effects on microclimate. Also, a wider plot would make it difficult to measure and evaluate changes in vegetation and surface soil conditions without walking or standing inside the plot. The plot length used was 30 to 32 feet (angled lower edge, fig. 1). This provided 310 square feet of runoff area.

PLOT CONSTRUCTION

Several kinds of construction were tried, but a runoff plot with the following features proved most efficient and economical.

Borders

Rough lumber treated with a wood preservative provided the cheapest and most effective plot border. The preservative dipping solution consisted of:

11.0 gallons	used crankcase oil
5.5 gallons	diesel oil
1.0 gallons	pentachlorophenol (10:1 concentrate)

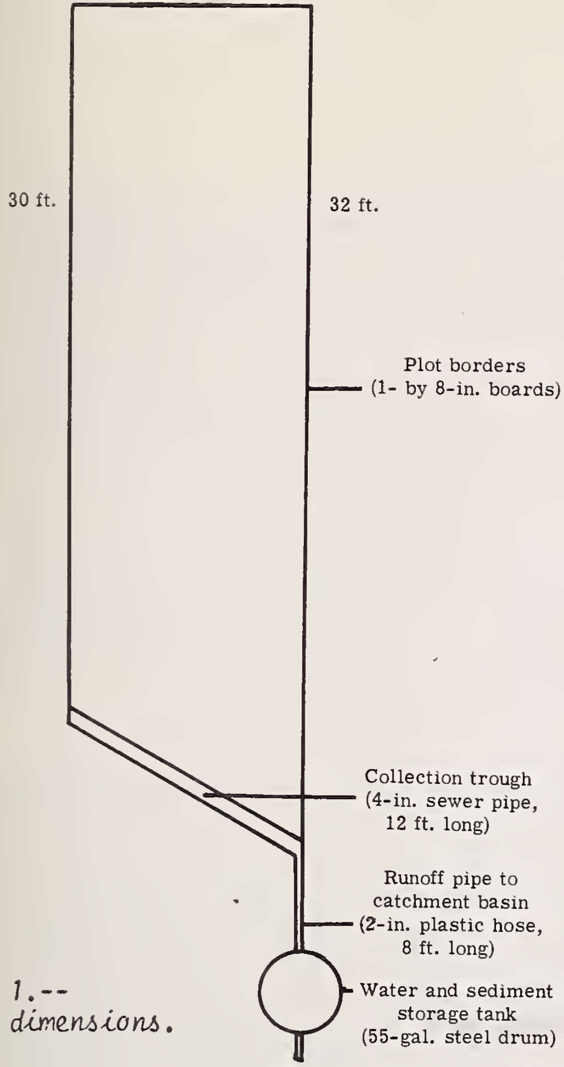
The lumber was dipped in this solution for 48 hours and stacked to dry. A 5 percent concentration of pentachlorophenol is recommended for optimum protection. The diesel oil used here was to thin the crankcase oil for faster penetration. Either the diesel or crankcase oil alone would suffice, but diesel oil alone is more costly and crankcase oil alone is absorbed slowly.

The plot area was measured and staked out with iron re-bars[4] at the four corners. The upper corners were squared along a chalk line (fig. 2). On the downhill end, the plot border was 2 feet longer on one side. A shallow trench was dug along the outer side of the chalk line on both sides and the upper end.

Boards were then placed against the re-bars used to mark the plot boundaries and another re-bar was placed at each outside corner to hold the boards in place (fig. 3). Additional re-bars were driven into the soil along the boards in a staggered pattern to insure firmness. Boards were joined where needed by butting ends and scabbing with an 18-inch piece of the same 1-by-8-inch material. Five nails were used on each side of the butt joint. Border corners, butt joints, and knots were sealed with calking compound (fig. 4).

After the plot wall was plumbed, loose soil was sifted along the crack between the board and the inside of the plot wall (fig. 5). The loose soil was next tamped with a half-inch board to secure the plot wall. Soil was then placed against the boards on the outside and tamped to within 1 inch of the top of the wood border (fig. 6). The above operations were carefully conducted to reduce soil and vegetation disturbance to a minimum within the plots.

[4] *Corrugated iron rod used for reinforcing concrete; commonly called re-bars when cut in short lengths.*



igure 1.--
Plot dimensions.

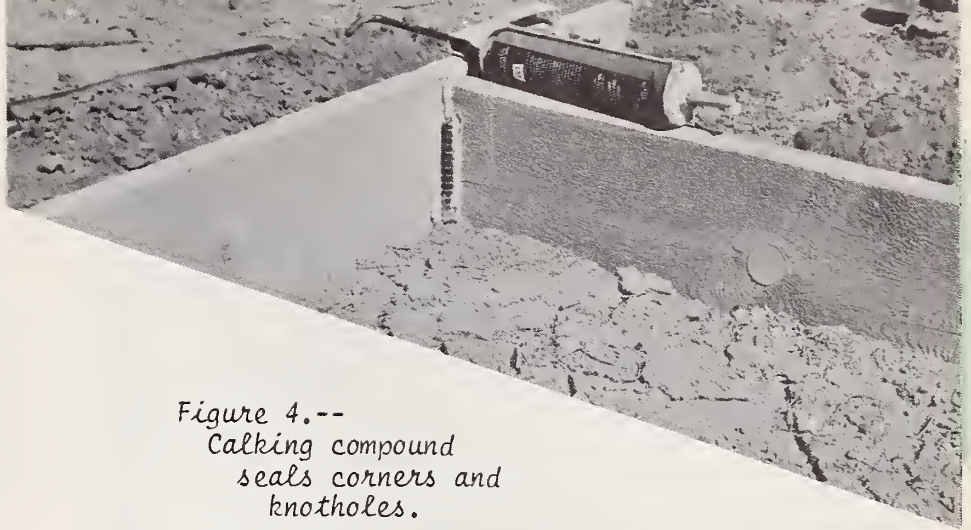


Figure 4.--
Calking compound seals corners and knotholes.

Figure 5.--
Soil is sifted into the crack between board and plot.

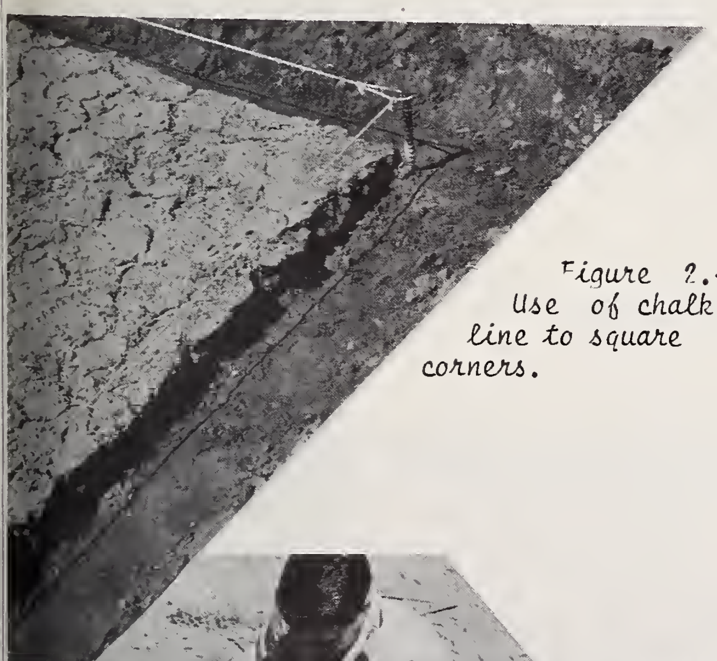


Figure 2.--
Use of chalk line to square corners.

Figure 3.--
Driving re-bar to hold plot border.

Figure 6.--
Soil is sloped and compacted on outside edge of plot.

Figure 7.--
Sealing the hose connector to the collection trough.

Collection Trough

Runoff water and sediment were collected by a slotted trough made from 4-inch sewer pipe, made of paper impregnated with asphalt. This pipe permitted muddy water to flow naturally over the trough-soil interface, enter, and flow freely down the pipe into the storage tanks or drums.

The installation of the collection trough required one 12-foot length of sewer pipe, two sealed couplings, one plastic hose connector, one radiator hose clamp, two re-bars, some plastic cement, and the following hand tools:

1. A pruning saw for use in cutting a 2-inch strip from the sealed couplings.

2. Brace and expansion bit to drill a hole for the plastic hose connector.

3. Two types of hammers -- a claw hammer for general use and a 4-pound hammer for driving re-bars into the ground.

4. A 2-foot level for obtaining a slope on the sewer pipe to insure proper drainage.

The collection trough was constructed by sawing a 2-inch slot along the length of a 12-foot section of pipe. The pipe ends were sealed with caps constructed from sewer-pipe couplings that had one end nailed closed with a wood disk. The caps were sealed both inside and out with plastic cement. A 2-inch strip was cut from each cap to coincide with the slot in the pipe.

A 3-inch-diameter expansion bit was used to drill a hole in the pipe for inserting the hose connector. The hose connector was sealed in the hole, flush with the inside of the pipe, with plastic cement (fig. 7).

A shallow trench was dug angling toward the lower edge of the plot. The pipe was placed in this trench, with the hose connector at the lower end, and held there by iron re-bars driven into the ground on the downhill side. The lower edge of the 2-inch slot was placed flush with the soil surface (fig. 8). The soil at the lip of the collection trough was tamped and sealed to the pipe with polyester resin. This prevented runoff water from undercutting the collection trough. A 2-inch plastic hose was clamped to the connector in the pipe with a radiator hose clamp (fig. 9). This hose, which led to the catchment basin, was placed in a 12-inch trench to prevent livestock damage by trampling.

Figure 8.--
Making the collection trough flush with the soil surface.

*Figure 9.--
Plastic hose clamped to connector in the collection trough.*

Catchment Basins

Metal drums (55-gallon capacity) were used to collect and store runoff and sediment (fig. 10). Six drums were necessary to accommodate the runoff from a rain of high intensity, in excess of 1.50 inches.

Two metal hose connectors were welded on opposite sides of the drums with one connector 1 inch higher than the other. The highest connector was joined to the runoff-plot hose, and the lower provided overflow to the succeeding drum. The drums were set in a trench perpendicular to and downslope from the runoff plots. The drums were anchored to steel fence posts by wires equipped with easily detachable couplings.

Drums could be placed far enough downslope to eliminate the need for a trench, but the extra hose required would be economical only on steep slopes. The drums could also be buried flush with the ground, which allows closer placement to the runoff plot, but a small centrifugal pump would be needed to empty runoff and sediment collected in the storage drums.

The drums may be either disconnected and overturned or emptied with a gasoline-powered pump. The latter course is recommended where 5 or more plots are installed at any one location.

*Figure 10.--
Metal drums used for catchment basins.*

COST OF RUNOFF PLOTS

Surface runoff plots as described are relatively inexpensive. Cost of plot materials approximates $26. Materials needed with specifications and prices [5] are tabulated below.

Item	Cost
4 steel drums (55 gallon)	([6])
12 ft. impregnated-fiber sewer pipe w/couplings @ 38¢	$4.56
4 steel 6 ft. posts (for drum anchorage) @ 93¢	3.72
Plastic cement	.03
8 radiator hose clamps @ 17¢	1.36
9 hose connections (2 in.) @ 52¢	4.68
74 ft. lumber @ $44/M bd.-ft.	3.26
Cutting and welding (Lids and couplings) @ $3.50/hr.	2.00
8 ft. plastic hose (2 in.) @ 38¢	3.04
22 iron re-bars @ 17¢	3.74
Wood preservative	.15
Total	$26.54

The construction and installation of each surface runoff plot required 1 man-day of labor, based on the construction of 84 plots by a 2-man team.

OTHER MATERIALS TESTED

Other less expensive materials were tested to determine which functioned most efficiently. Methods of construction and types of materials were tested throughout the fall and winter of 1958-59.

[5] *Costs are for April 1962 at Albuquerque, New Mexico.*

[6] *Barrels were acquired free of charge from Government surplus stocks.*

Figure 11.--
Soil mound border was unsatisfactory.

Plot Borders

A soil ridge or mound was first tried as a plot border (fig. 11). Soil was mounded to a chalk line at a height of 8 inches. Although this method was the most economical, the borders were disturbed by the trampling of livestock. Also, wind and rain eroded the borders, which increased the sediment load of surface runoff. This method was discarded.

In the second method, 1-by-8-inch rough lumber was used for plot borders. The boards were placed in a 3-inch trench along the plot boundaries and secured in place with 2-foot iron re-bars. Loose soil was tamped in the fissures along the soil-board interface. Soil was tamped outside the wood borders to the original ground level (fig. 12). This method was rejected because the boards alone were not sufficiently rigid to withstand the disturbances by grazing livestock and the action of wind and rain.

The third method was similar to the second, but provided additional support to the wood borders by banking soil against the boards outside the plots (fig. 13). This method proved quite satisfactory, as it gave the additional support and protection needed against wind action and trampling livestock.

Collection Troughs

Three methods of collecting runoff and sediment were tried.

Diversion toward the middle at the lower end of the runoff plot by the use of a V-shaped border (fig. 12) was discarded for two reasons: (1) runoff concentration at the apex of the V necessitated too large a trough and hose, and (2) a great deal of trouble was encountered with litter clogging the V.

In the second method, a collection trough the width of the plot was placed perpendicular to the long axis of the plot. Since the terrain even on small plots usually slopes one way or the other, an excessive amount of soil disturbance was necessary within the confines of the plot itself. This method was also discarded.

The third method was essentially the same as the second except that the trough was placed at an angle across the lower end of the plot. Direction of the angle conformed to the slope of the terrain. This method functioned well and required a minimum of soil disturbance.

Figure 12.--
Wood border alone was unsatisfactory.

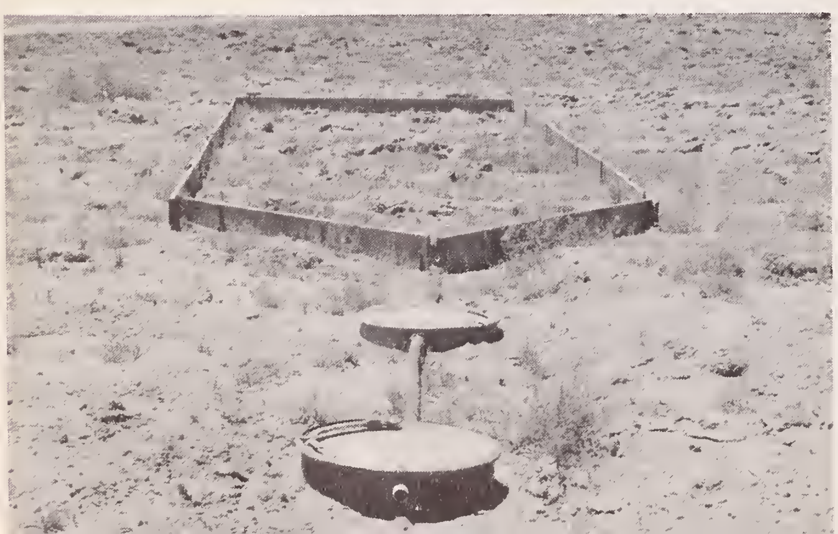


Figure 13.--
Wood border banked with soil on outside proved the most effective. Note the V-shaped collection trough.

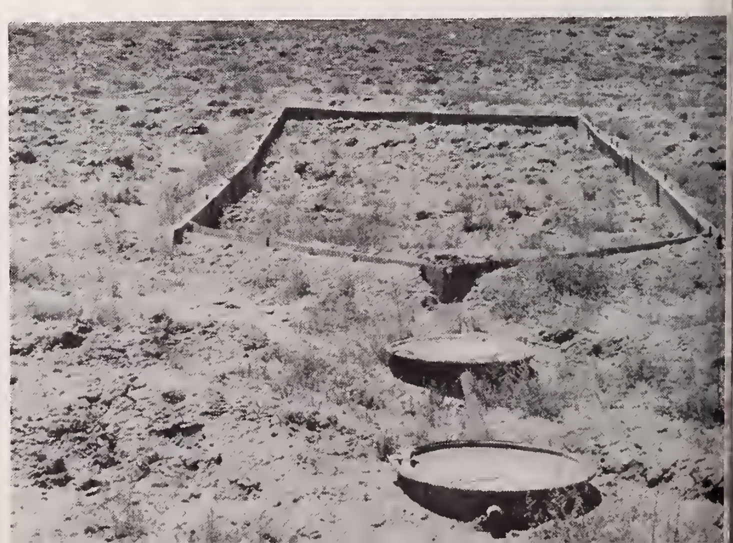
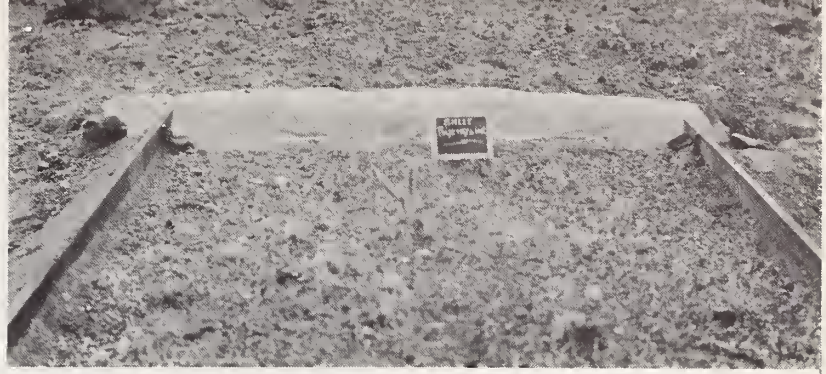
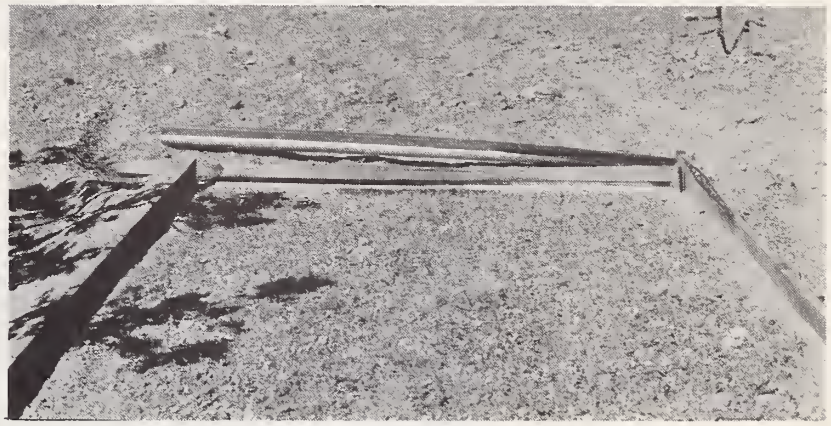


Figure 14.--
Materials tested for collection trough:



A, polyethylene sheeting;

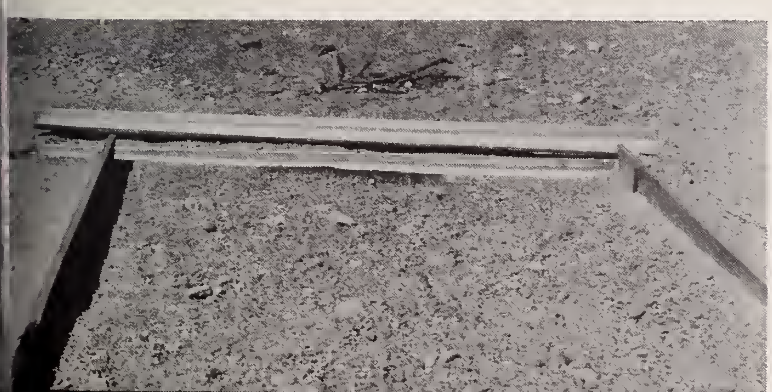


B, roofing ridge;

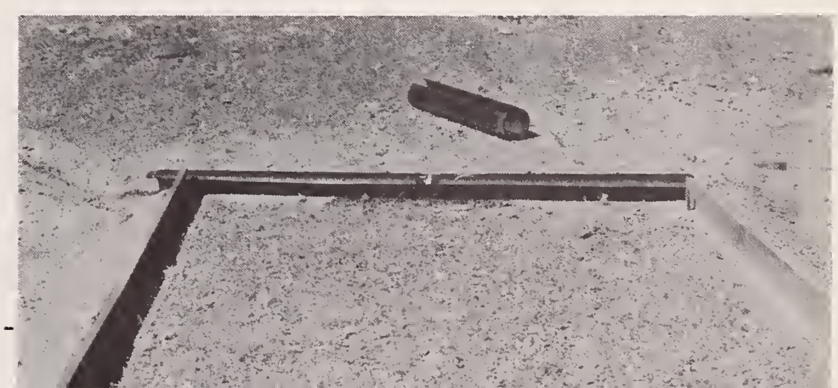
C, roofing valley;

D, wooden frame;

E, roofing gutter;



F, impregnated-fiber sewer pipe.



Trough Materials

Six different materials were tested for their ability to conduct runoff and sediment moving at a high rate of speed. Materials tested were (fig. 14): A, polyethylene sheeting; B, roofing ridge; C, roofing valley; D, a wooden frame; E, roofing gutter; and F, impregnated-fiber sewer pipe. Of these materials, only the sewer pipe with a 2-inch slot handled all of the runoff produced during the preliminary tests.[7] In contrast, the other materials caused sediment to be dropped at the trough-soil interface, in the trough itself, or at the hose connections. This impeded the flow of runoff water and the trough usually overflowed.

[7] *Flow from 100 gallons of water dumped instantaneously at the upper end of a 10- by 10-foot test plot was entirely collected by the sewer pipe. This quantity of water amounted to 1.6 area-inches and required about 2 to 3 seconds to traverse the 10 feet downslope.*

SUMMARY

Construction and installation of a simple, inexpensive runoff plot for measuring surface runoff and erosion are described. One-by-eight-inch boards are used for the frame, supported by dirt mounded against the outside. A slotted, impregnated-fiber sewer pipe 4 inches in diameter forms the collection trough at an angle across the bottom of the 10-by-30-foot plot. Runoff flows by gravity through a hose into collection barrels in a trench.

The materials considered best cost roughly \$26 per plot. One man-day was required to build one of these plots. Several other materials and shapes of collection troughs tested were discarded as impractical.

Eighty-four of these surface runoff plots have been in constant operation for 4 years. To date, no repairs have been necessary (fig. 15). Maintenance consists simply of removing Russianthistle plants that collect in the trenches, and an occasional mouse nest in the collection troughs.

Figure 15.--Corner of plot border and collection trough 4 years after installation. No maintenance was needed.

Agriculture --- CSU, Ft. Collins